

The magnetic interactions of RuCl_3 can be described through the frustration of Heisenberg spin exchanges

ABSTRACT:

The new field of Dirac quantum matter has produced a lot of interesting theories and materials, especially in the dynamics of magnetic materials. One such material is RuCl_3 , which is a $S = 1/2$ zigzag honeycomb lattice. Through inelastic neutron scattering, this material has demonstrated spin waves with an energy scale of 1.5-8.0 meV. According to literature, RuCl_3 may be the realization of a new theoretical phase of matter called a spin liquid. This materials seems to fit the profile and has been investigated using a Kitaev model. In this study, we re-examine the data for RuCl_3 using a standard Heisenberg spin-spin exchange model with easy axis anisotropy. By imposing a Holstein-Primakoff expansion and utilizing competing exchange interactions within the zigzag magnetic configurations of RuCl_3 , we provide insight into the evolution of the spin dynamics. By analyzing the system by adding frustration, we are able to demonstrate that a standard Heisenberg model can produce an accurate model of the observed spin waves is produced. Therefore, with simpler model describing the spin dynamics of RuCl_3 , we ultimately shed some doubt on the current considerations of RuCl_3 as a quantum spin liquid.

MODEL:

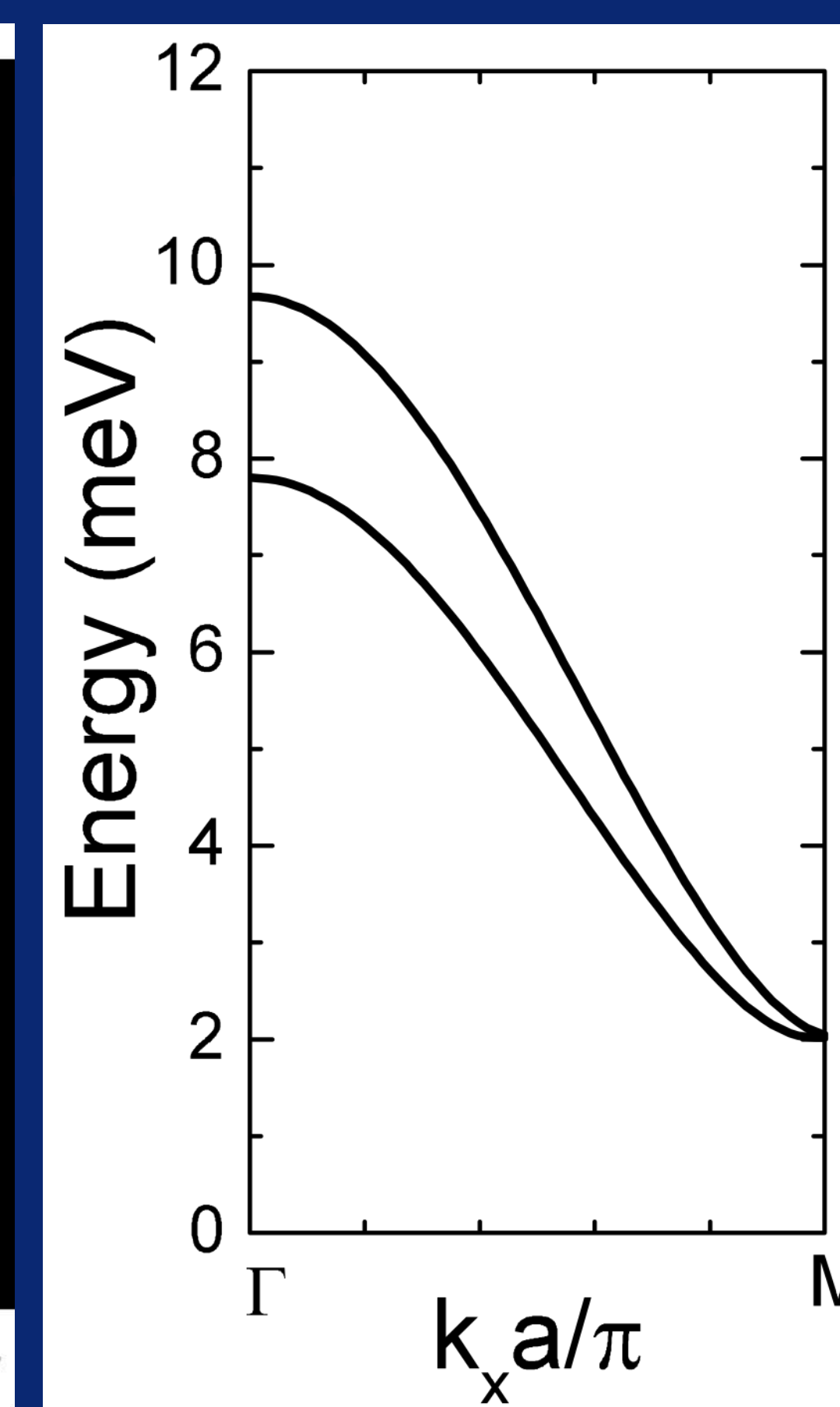
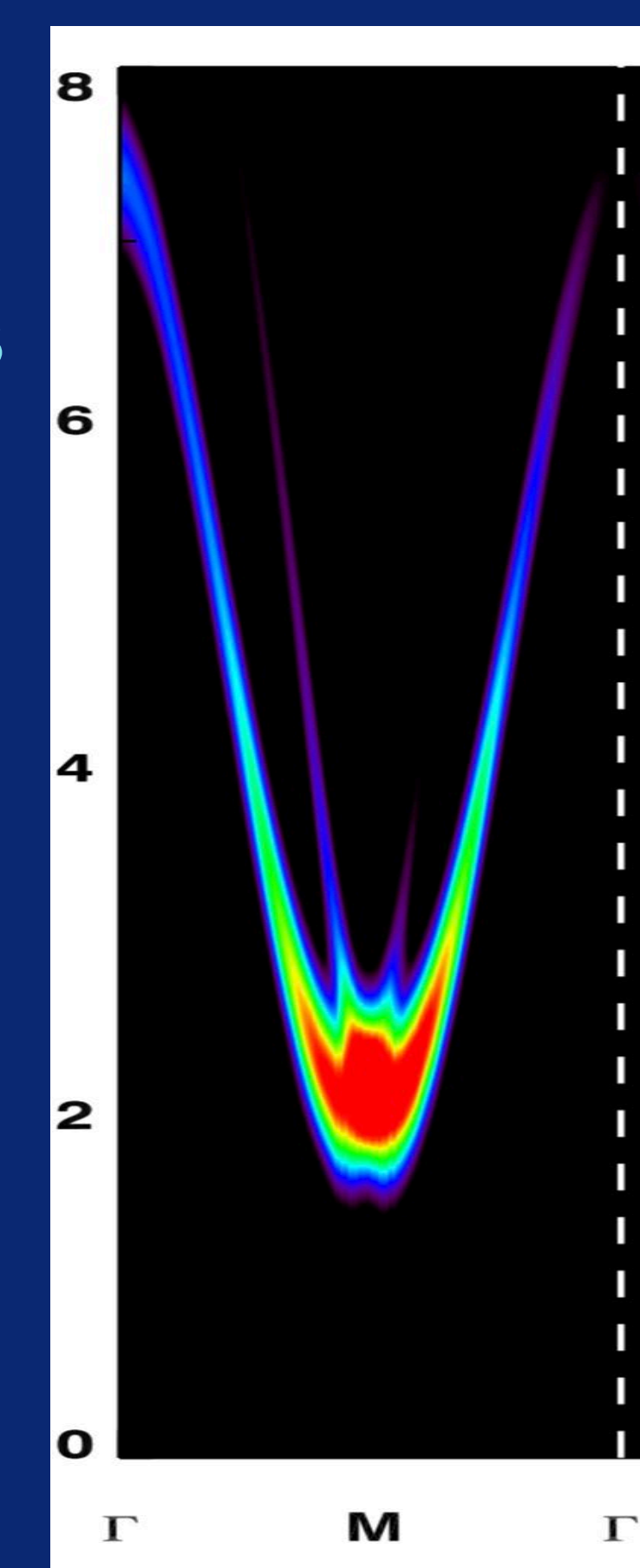
Using a Heisenberg spin-spin exchange Hamiltonian, we examine the spin-wave dynamics and excitations for the zig-zag magnetic configuration of the honeycomb lattice. Using a model that incorporates variable nearest neighbor and next-nearest neighbor interactions, we investigate their effects on the overall energy and spin-wave dynamics. Through a comparison of the various model parameters, we find that the observed inelastic neutron scattering excitations in RuCl_3 may be a realization of spin frustration with spin-orbit coupling and not necessarily due to the presence of a quantum spin liquid. Future calculation of the spin wave intensities will hopefully clarify this model.



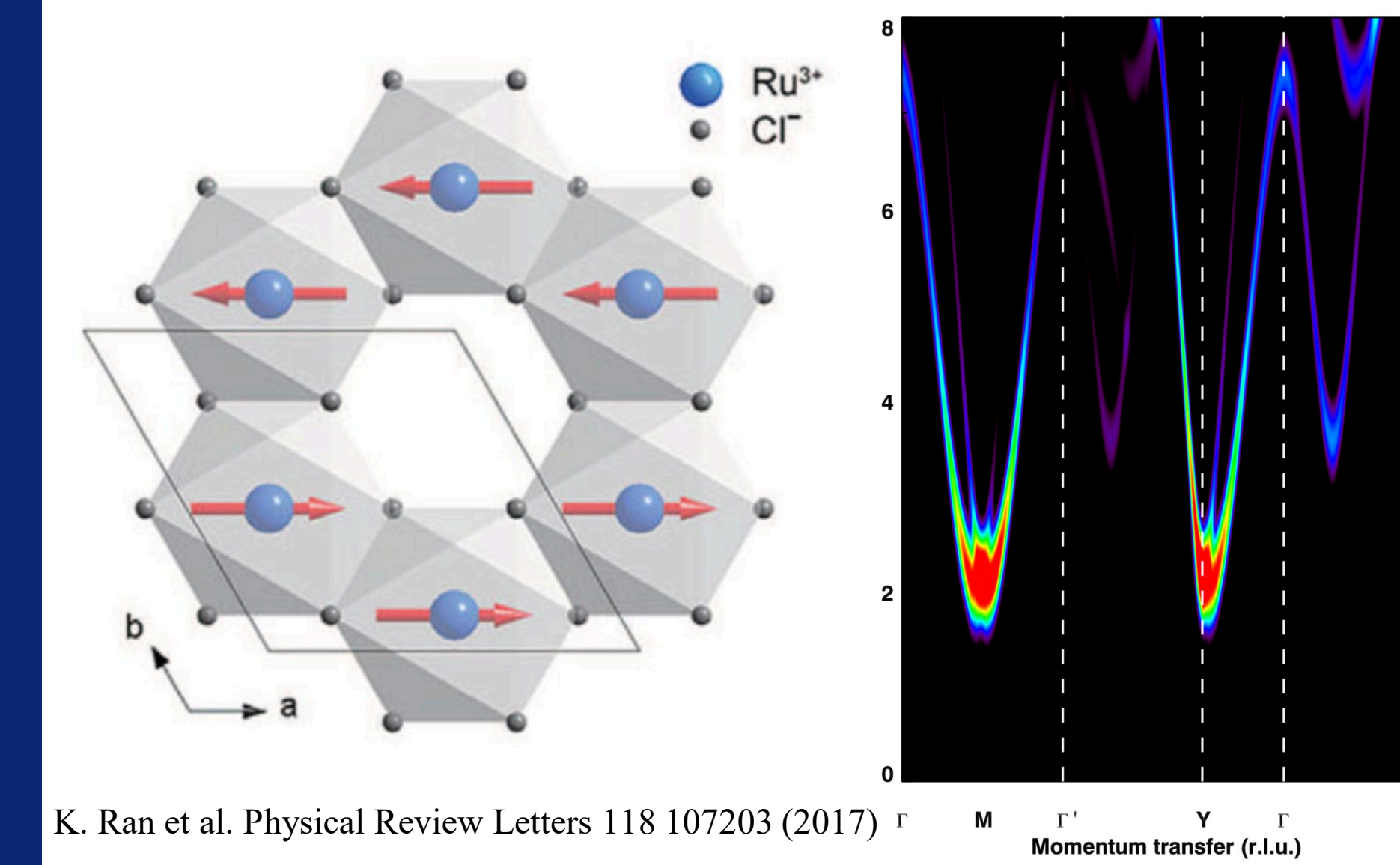
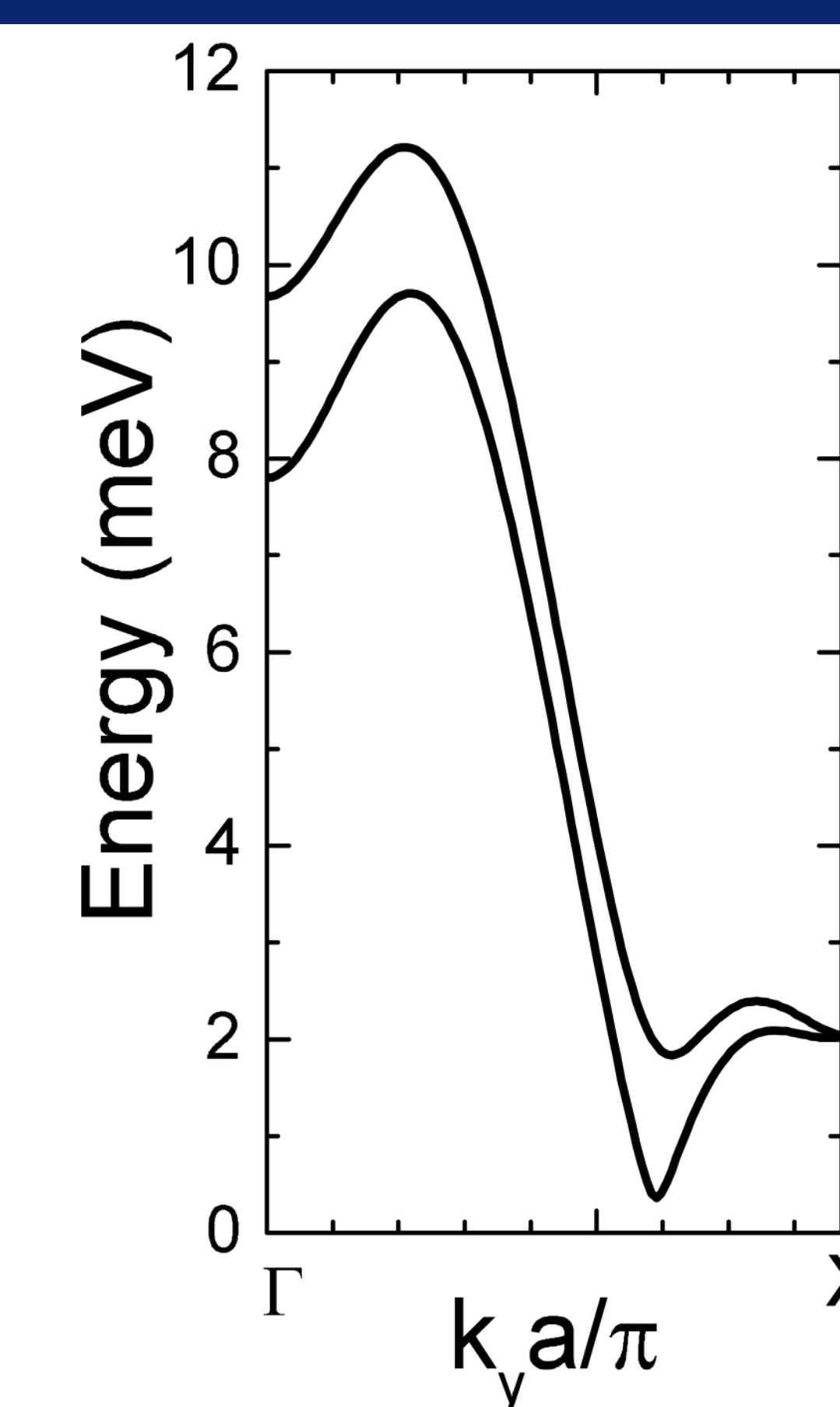
Take a picture to
go to the UNF Materials
Theory website



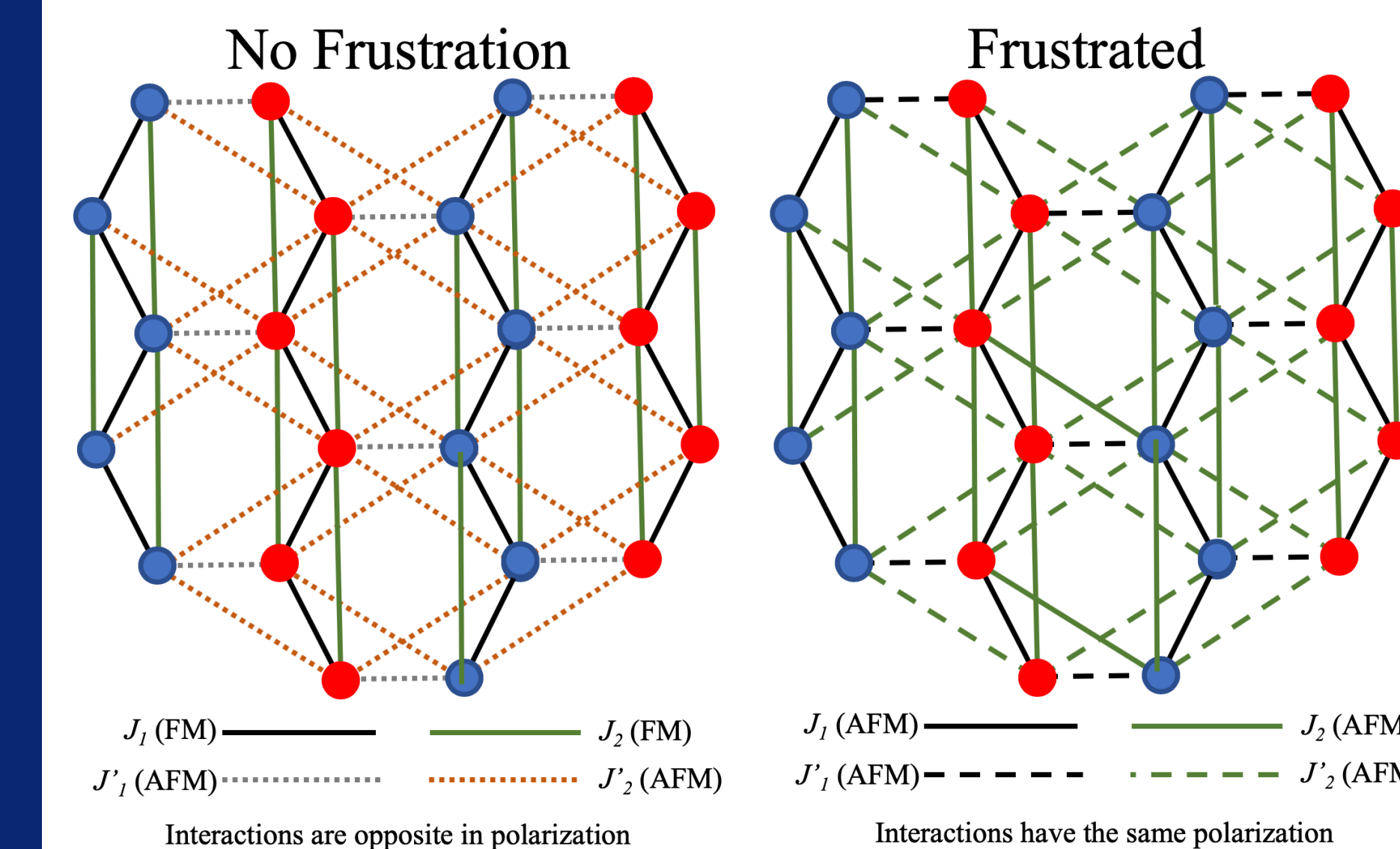
SCAN ME



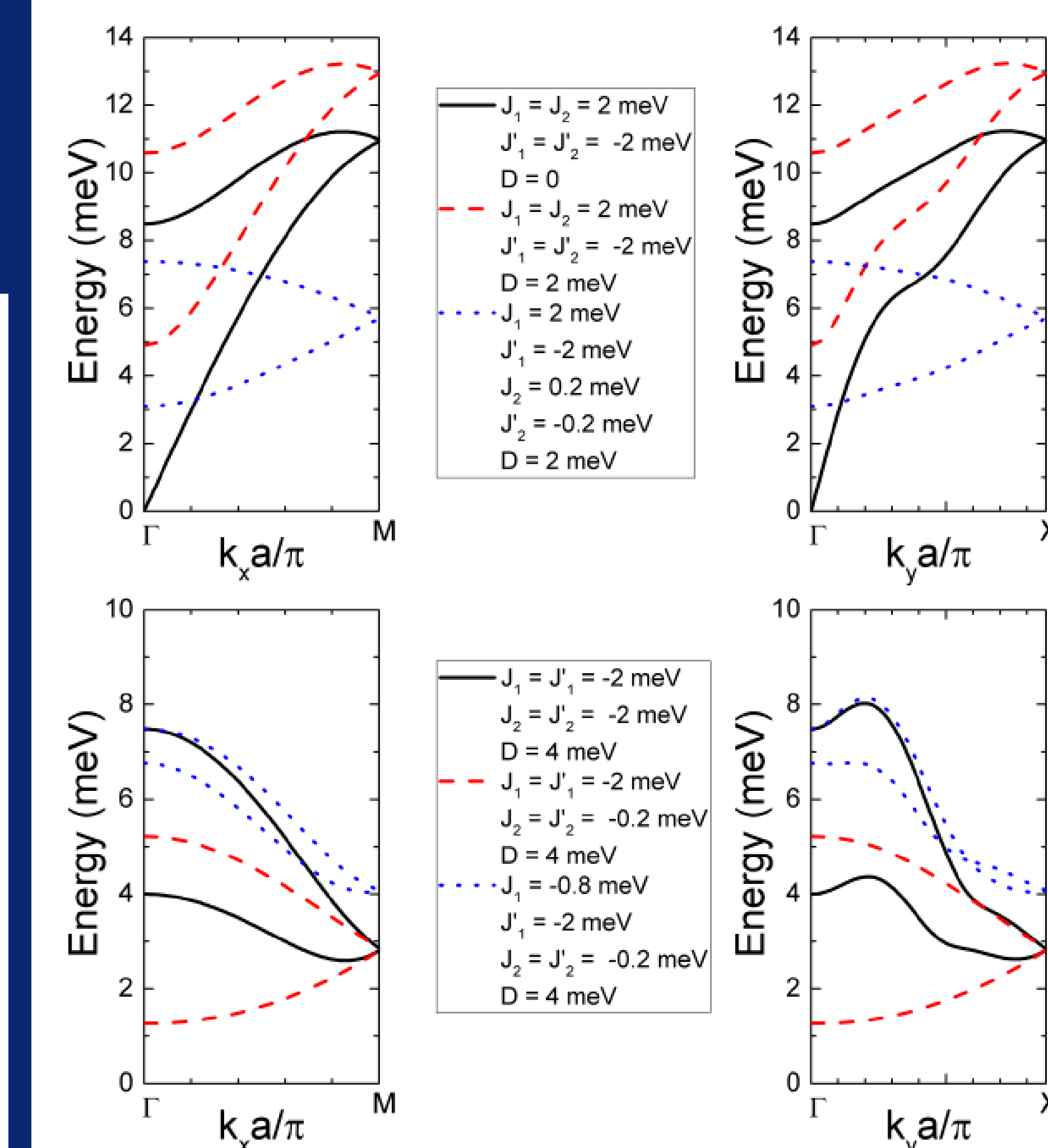
$J_1 = -0.8 \text{ meV}$
 $J'_1 = -0.4 \text{ meV}$
 $J_2 = -5.2 \text{ meV}$
 $J'_2 = -4.4 \text{ meV}$
 $D = 4.2 \text{ meV}$



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No Frustration Model ↓



Frustration Model ↑